Health Consultation

Old Fort Municipal Well #2A
Old Fort, North Carolina

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Prepared by:

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Purpose

In response to a citizen petition, the North Carolina Health Assessment, Consultation, and Education Program (HACE) evaluated possible chemical exposures related to the Old Fort Finishing industrial site located in Old Fort, North Carolina. The specific concern was that students and staff at nearby Old Fort Elementary School were exposed to chemicals by groundwater, through the sewer system and by air movement from vehicle traffic along the adjacent I-40 interstate highway. The 2010 report concluded that no apparent health hazard existed for trichloroethylene (TCE) or tetrachloroethylene (PCE). It also concluded that prolonged inhalation of radon at the exposure levels measured at the school could harm people's health [ATSDR Old Fort].

The citizen subsequently raised additional concerns about potential chemical exposures at Old Fort Elementary School resulting from contaminated municipal water leaking into the ground from the municipal sewer collection system. A second scenario raised was that chlorinated solvents from a near-by former dry cleaning operation contaminated groundwater beneath the school. In both instances, the concern was potential student and staff chemical exposures created by vapor intrusion of chlorinated solvents from the contaminated groundwater.

The objective of this report is to address the vapor intrusion concerns and to determine if the connection of well #2A to the municipal drinking water system and resulting consumption of contaminated water could have harmed people's health.

Background

Municipal Water

The Town of Old Fort currently relies on four municipal wells to provide drinking water. The combined capacity of the wells is 870 gallons per minute. The water is disinfected at the wellhead and pumped to storage tanks with 200,000 gallon and 500,000 gallon capacities. The well pumps are triggered when the water level drops below 75 percent capacity in the smaller storage tank. Well #5, #9, and #10 are located about one mile northeast of the Old Fort Finishing site. Well #2 is located about one mile southwest of the Old Fort Finishing site.

Well #2A was owned by United Merchants and Manufacturing Company and donated to the Town of Old Fort after the Old Fort Finishing plant was closed in 1984. The capacity of the well was 600 gallons per minute and it was located 0.25 miles east of the Old Fort Finishing site (see Appendix A). The former operator of the municipal water system indicated water usage was about 400,000 gallons per day in the mid-1980s. He had worked at the Old Fort Finishing facility until it closed in 1984 and began working for the Town of Old Fort in 1987. He estimated that well #2A was connected to the municipal system for 2.5 years.

Drinking water samples were first collected at well #2A on December 1, 1987. Repeat testing was performed on December 22, 1987. Tetrachloroethylene and trichloroethylene concentrations exceeded recommended levels in both samples. In January 1988, the town was instructed by the Division of Public Health (DPH) not to use well #2A for drinking water.

Testing of well #2A was repeated 2 more times after the well was no longer connected to the municipal supply. The highest concentration of contaminants was detected in the final data set collected in September 1989, which was more than 18 months after well #2A was disconnected from the municipal water system. To be health protective, the highest concentration measured was compared to the Agency for Toxic Substances and Disease Registry's (ATSDR) comparison value (see Table 1).

Drinking water sampling was also performed at five residences and one small commercial well that were identified near the Old Fort Finishing site. No contaminants were detected in three private well drinking water samples collected in January 1989. However, trichloroethylene and tetrachloroethylene levels exceeded recommended levels in the three additional private drinking water wells that were identified and sampled in the fall of 1989 (see Table 2). The residents were instructed not to drink the water and were connected to the municipal water system. The names of the individual well owners are not used in the report for privacy reasons.

The population of concern for this site is people who used the Old Fort municipal water system while well #2A was connected to the system. This includes schools, businesses, and homes. It also includes people living near the Old Fort Finishing site who used contaminated private drinking water wells. The 1990 U.S. Census data indicated that the Town of Old Fort had 720 residents. Disconnecting well #2A in 1988 and converting residents with contaminated private wells to the municipal water in 1989 eliminated current and future points of exposure.

Old Fort Municipal Sewer System

In August 1989, McGill Associates performed a study of the water and sewer systems in McDowell County [McGill Associates]. The report concluded that Old Fort's collection system was "basically sound and adequate for existing and proposed flows." The report also discussed that the downtown area is served by 3,600 linear feet of 6 inch sewer lines and no major maintenance problems had occurred with these lines. The report did discuss maintenance issues and intake leaks at the municipal wastewater treatment plant. The waste treatment plant is located more than a mile northeast of Old Fort Elementary School.

The current and former operators of the Old Fort municipal water and sewer system were also contacted. They were not aware of any significant water or sewer system leaks in the vicinity of Old Fort Elementary School during the mid-1980s.

There is no evidence that the municipal sewer system had significant leaks in the vicinity of the school. Any leaks that occurred at the wastewater treatment facility were unlikely to affect the school because of the distance from the school and direction of groundwater flow. Therefore, no further discussion of the municipal sewer system is warranted.

Nichols Laundry and Dry Cleaning site

The Nichols Laundry and Dry Cleaning site is located approximately 700 feet north west of Old Fort Elementary School. It was added to the N.C. Department of Environment and Natural Resources' Dry-cleaning Solvent Cleanup Act (DSCA) program in December 2009. Extensive sampling of the groundwater was performed in 2010 and 2011 to define the extent of the

contamination. The site assessment also included soil, surface water, ambient air, and soil gas samples. The DSCA program is currently conducting periodic monitoring of conditions at the site. The groundwater flow from the Nichols Laundry and Dry Cleaning site is generally towards Old Fort Elementary School. Dry-cleaning operations at the site ceased over a decade ago and the building is currently occupied by a Laundromat and flower/gift shop [Hart and Hickman 2010].

Groundwater monitoring wells on-site and off-site detected chlorinated chemicals and petroleum products in the groundwater. Sub-slab vapor monitoring and soil samples at the site confirmed the presence of tetrachloroethylene. Additional groundwater monitoring wells were installed and sampling was performed in March 2011 in an effort to define the boundaries of the plume of contamination. Trichloroethylene and tetrachloroethylene were measured in groundwater across Mills Creek from the drycleaner (see Figure 1). However, they were not detected in the monitoring well closest to the school [Hart and Hickman 2011]. Guidance documents from EPA and the Interstate Technology and Regulatory Council state that vapor intrusion is unlikely when the contaminant plume is more than 100 feet (laterally and vertically) from a building. Vapor intrusion is not expected at the school at this time because the plume of contamination is more than 100 feet from the school. Vapor intrusion at the Gateway Museum and former drycleaners will be discussed in more detail in this report.

Method

Drinking Water Data

A two-step process is used to evaluate chemicals' potential for producing adverse health effects. The first step is to screen each chemical against comparison values (CVs). The comparison values are concentrations of chemicals in the environment (air, water, or soil) below which no adverse human health effects would be expected to occur. If a contaminant is present at a level higher than the corresponding CV, the contaminant of concern is retained for the next step of evaluation.

The second step of evaluation focuses on identifying which chemicals and exposure situations could be a health hazard. To identify the greatest potential for negative health effects, we used the highest concentration of a substance detected in drinking water. We estimate amounts of a contaminant that people come in contact with and may get into their bodies on an equivalent body weight basis (the "exposure dose"). Each calculated exposure dose is compared against the corresponding health guideline, typically an ATSDR Minimal Risk Level (MRL) or Environmental Protection Agency (EPA) reference dose (RfD). Health guidelines are considered safe doses; that is, if the calculated dose is at or below the health guideline, no adverse health effects would be expected.

The dilution of the contaminated water by clean water from the non-contaminated wells in the water storage tank or off-gassing in the storage tank was not factored into the calculation of exposure doses. Well #2A was one of five municipal wells and it provided about 41 percent of the system water capacity. The former municipal water operator stated that each well was triggered sequentially instead of simultaneously with the other four wells. Once the low-level

switch in the water tank triggered one of the wells, the well operated until the water tank was filled. Although some dilution likely occurred in the storage tank it is not possible to accurately estimate the value because the amount of time the well operated and the length of time water remained in the storage tank fluctuated with demand.

Estimates of increased numbers of cancers are calculated for known or suspected cancer-causing contaminants using the estimated site-specific exposure dose and cancer slope factor (CSF) provided in ATSDR health guideline documents. This cancer risk estimate is based on the assumption that there is no safe level of exposure to a chemical that causes cancer. A four-year exposure period was selected for the municipal water because it is a worst-case estimate of the length of time the town used water from well #2A based on interviews with regulators and the former wastewater system operator. Age specific water consumption rates and body weight were used to calculate exposure doses [EPA EF 2011]. A 33-year exposure period was used to evaluate cancer risks for the private drinking water wells. This time period approximates the maximum time (95^{th} percentile) a person is expected to live at one location. We do not know when the contamination occurred, when the contaminants initially reached the wells, or how long the private wells were used.

A number of studies have shown people may be exposed to volatile organic chemicals from contaminated water while showering, bathing, and cooking. The contaminants are volatilized from the water droplets and can be inhaled. Some chemicals may also be absorbed through the skin. The inhalation/dermal exposures are generally considered comparable to ingestion. The estimated exposure dose used to evaluate adverse health effects was doubled to account for inhalation/dermal exposures from showering.

Inhalation

A process similar to the one described above for ingestion was followed for inhalation due to vapor intrusion. The chemical contaminants detected in air samples (flower shop and museum) were compared to ATSDR and EPA screening values. Only air samples collected in the occupied space were used in the evaluation. We performed a more detailed evaluation if the contaminants levels exceeded the screening levels. Standard occupational exposure factors (25 years, 250 days, 8 hrs/day) were used in the evaluation.

Results

Drinking Water

Drinking water samples were collected before and after well #2A was disconnected from the municipal system. Up to seven chlorinated chemicals were detected in the samples (see Table 1). The highest levels were in the last sample more than 18 months after the well was closed. The highest concentration of a contaminant was used in the evaluation process to determine the risk of adverse health effects. Four chemicals were present at levels above ATSDR’s Comparison Values (CV). A more detailed analysis was performed for these chemicals to determine the potential for adverse health effects.

Table 1: Municipal Well #2A Analytical Data and Health Comparison Values

Contaminant	12/1/87 µg/L[1]	12/22/87 µg/L	1/31/89 µg/L	9/6/89 µg/L	CV[2] µg/L	Type of CV
Carbon tetrachloride	ND[3]	ND	<1	ND	0.5	CREG[4]
					40 child 100 adult	RMEG[5]
Chloroform	ND	<5	2.6	ND	100 child 400 adult	Chronic[6] EMEG
1,1-Dichloroethene	ND	<5	4.6	2.6	90 child 300 adult	Chronic EMEG
Cis-1,2-Dichloroethylene	22	19	13.8	79.1	20 child 70 adult	RMEG
Tetrachloroethylene	4.8	75	90.8	448.4	10	LTHA[7]
					17	CREG
1,1,1-Trichlorethane	ND	ND	1.1	ND	200	LTHA[7]
Trichloroethylene	62	191	168.1	790.9	5 child 18 adult	Chronic EMEG
					0.76	CREG

Note: Gray shading indicates concentration exceeded the CV.
[1] µg/L = Micrograms per Liter
[2] CV = ATSDR Comparison Value for Drinking Water
[3] ND = Not Detected
[4] Cancer Risk Evaluation Guide
[5] Reference Dose Media Evaluation Guide
[6] Chronic Environmental Media Evaluation Guide
[7] Lifetime Health Advisory for drinking water (EPA)

Age-specific water consumption rates and body weights were used to calculate an exposure dose. The exposure dose was calculated based on the reasonable maximum exposure (highest) water intake rates and central tendency exposure (average) water intake rates. The exposure dose exceeded the Minimal Risk Level (non-cancer) for trichloroethylene, tetrachloroethylene, and cis-1,2-dichloroethylene (see Table 4, Appendix C). The increased cancer risk was also calculated for carbon tetrachloride, trichloroethylene, and tetrachloroethylene (see Table 6, Appendix C). Additional detail is provided in the substance specific discussion.

Six private drinking water wells were also sampled in 1989. No contaminants were detected in three of the wells. However, trichloroethylene and tetrachloroethylene levels exceeded recommended exposure levels in 3 private wells (see Table 2). The wells were disconnected and the residents were connected to the municipal water system in 1989. The trichloroethylene and tetrachloroethylene levels exceed current CVs.

Table 2: Private Drinking Water Data Analytical Data and Health Comparison Values

Contaminant	**Well #1 µg/L[1]**	**Well #2 µg/L**	**Well #3 µg/L**	**Well #4 µg/L**	**Well #5 µg/L**	**Well #6 µg/L**	**CV[2] µg/L**	**Type of CV**
1,2-Dichloroethene	ND[3]	ND	ND	9.1	3.9	4.2	20 child 70 adult	RMEG[4]
Tetrachloroethylene	ND	ND	ND	126.6	44.7	51.9	10	LTHA[5]
							17	CREG[6]
Trichloroethylene	ND	ND	ND	39.0	15.1	38.5	5 child 18 adult	Chronic[7] EMEG
							0.76	CREG

Note: Gray shading indicates concentration exceeded the CV.
[1] µg/L = Micrograms per liter
[2] CV = ATSDR Comparison Value
[3]ND = Not Detected
[4]Reference Dose Media Evaluation Guide
[5] Long Term Health Advisory
[6]Cancer Risk Evaluation Guide
[7]Chronic Environmental Media Evaluation Guide

The exposure dose calculated for tetrachloroethylene exceeded the MRL (non-cancer) for children less than 11 years of age for all three wells when the dose was doubled to include inhalation exposures from showering. The trichloroethylene exposure dose exceeded the MRL for all age groups in all three private wells (see Table 5, Appendix C). The increased cancer risk based on the highest exposure was calculated (see Table 7, Appendix C).

Vapor Intrusion/Inhalation

Indoor air levels of contaminants were measured in the flower shop (formerly Nichols Laundry) and the nearby Gateway Museum in September 2010. Air samples were collected over an eight-hour period using Summa canisters. Trichloroethylene (TCE) and tetrachloroethylene (PCE) were detected in the occupied area of both buildings [Hart and Hickman 2010]. Trichloroethylene was also detected in the background sample outside the Gateway Museum at a concentration above the CV.

Air sampling was repeated in the Gateway Museum in April 2012 and July 2012 [Hart and Hickman 2012]. The PCE concentration increased from 1.7 $\mu g/m^3$ in 2010 to 3.6 $\mu g/m^3$ in 2012. The TCE concentration decreased from 11$\mu g/m^3$ in the 2010 sample to 0.1 $\mu g/m^3$ in the 2012 samples. The background (outside air) concentration of TCE also decreased to a concentration less than the CV in the 2012 samples. The air sampling results are listed in Table 3.

Table 3: Ambient Air Chemical Concentrations

Description	Location	PCE [1] µg/m³			TCE[1] µg/m³		
		9/17/10	4/19/12	7/18/12	9/17/10	4/19/12	7/18/12
Flower shop	Inside	24	NA	NA	1.1	NA	NA
	Outside Bkgd	<0.25	NA	NA	<0.20	NA	NA
Museum	Crawlspace	3.7	2.9	4.3	27	0.13J[2]	0.1J[2]
	Inside 1st floor	1.7	2.6	3.6	11	0.1J[2]	0.1J[2]
	Outside Bkgd	<0.24	0.14J[2]	0.34	7.7	<0.19	0.21J[2]
Comparison Value	RfC[3]	40			2		
	CREG[4]	3.8			0.24		

[1]Micrograms per Cubic Meter of Air
[2] Estimated Concentration
[3] EPA Reference Concentration
[4] Cancer Risk Evaluation Guide

The highest concentration of a contaminant was used in the evaluation process to determine the risk of adverse health effects. The PCE concentration did not exceed the non-cancer comparison value in the flower shop or museum. The highest TCE exposure was less than the non-cancer CV after the application of occupational exposure factors. The excess cancer risk was calculated for both locations (see Table 8, Appendix C). No additional risk was documented for PCE. The calculated excess cancer risk for TCE was very low.

Substance by Substance Discussion

Carbon Tetrachloride

Carbon tetrachloride is a clear volatile liquid that does not occur naturally in the environment. It was used as a cleaning solution, fumigant, and refrigerant. People can be exposed to carbon tetrachloride by inhalation, ingestion, or absorption through the skin. High exposures can result in liver, kidney, and central nervous system damage.

Animal studies demonstrated that exposure to carbon tetrachloride can cause liver cancer. Animal studies also confirmed the primary non-cancer effect of chronic oral exposure is liver damage [ATSDR Carbon Tetrachloride]. The U.S. Department of Health and Human Services (DHHS) has determined that carbon tetrachloride may reasonably be anticipated to be a carcinogen. The International Agency for Research on Cancer (IARC) has classified carbon tetrachloride as possibly carcinogenic to humans. EPA has determined that carbon tetrachloride is “likely to be a human carcinogen” [IRIS Carbon Tetrachloride].

Carbon tetrachloride was detected in one of the four well #2A water samples. The concentration was reported as “less than” 1 µg/L because it was too low to accurately quantify. Carbon tetrachloride was not detected in any of the private well samples. The maximum concentration (1 µg/L) was below the ATSDR screening value for non-cancer adverse health effects. The additional cancer risk was less than 1 case per million people exposed.

cis-1,2 Dichloroethylene

cis-1,2 Dichloroethylene (DCE) is a chlorinated solvent that is used in industry to dissolve resins, as a refrigerant, and to manufacture pharmaceuticals. It may be released directly to the environment by these industrial processes. However, DCE is also formed in the soil and groundwater as microbes breakdown TCE and/or PCE contamination.

There are no human studies on the adverse health effects of DCE. Animal studies identified an increase in liver weight, an increase in kidney weight, and a decrease in red blood cell levels after oral exposure to DCE. EPA concluded there is not enough information available to determine if DCE can cause cancer [IRIS DCE].

The exposure dose was calculated based on the highest concentration of DCE measured in the municipal water. The exposure dose exceeded EPA's health guideline for all age groups if the reasonable maximum water intake rates were used in the calculation. Children under two years of age exceeded EPA's health guideline if the mean water intake rates were used. The exposure dose for people (doubled to account for showering) was less than 0.5% of the exposure dose ($BMDL_{10}$: 5.1 mg/kg-day)1 estimated to cause an increase in kidney weight in animals. If the DCE concentration at the time the well was closed is used in the calculation, the exposure dose is 0.1% of the exposure dose in animals that caused an increase in kidney weight [IRIS DCE]. There are uncertainties associated with extrapolating animal data to humans. There is also uncertainty associated with accounting for an individual's susceptibility or sensitivity to chemicals. However, health protective assumptions were used throughout the evaluation process. Adverse health effects are not anticipated from DCE contamination of the municipal water. The DCE concentration in the private wells was less than CV and no adverse health effects are anticipated.

Tetrachloroethylene

Tetrachloroethylene (PCE) is a chemical widely used for dry cleaning and for metal-degreasing operations. Exposure can occur from use of consumer products or as a result of improper disposal practices. Epidemiology studies have shown a link between drinking PCE contaminated water and lower birth weights for infants [ATSDR PCE]. Animal studies show that PCE can damage the liver, kidney, central nervous system, reproductive system, and fetus.

It has also been shown to produce liver cancer, kidney cancers, and leukemia in some animals. There is limited human data that shows exposure to PCE may be associated with esophagus, lymph system, cervix, bladder, kidney, and lung cancers. However, there is insufficient information to conclusively prove the link in humans. The U.S. Department of Health and Human Services has determined that PCE may reasonably be anticipated to be a human carcinogen. The IARC concluded PCE is "probably carcinogenic in humans" and EPA concluded that PCE is "likely to be carcinogenic in humans" [IRIS PCE].

The exposure dose that was calculated based on drinking the highest concentration of PCE in the municipal well exceeded EPA's (non-cancer) health guideline for all age groups. The calculated

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1 $BMDL_{10}$ is the 95% lower confidence limit on the benchmark dose corresponding to a 10% increase in relative kidney weight compared to controls

exposure dose, that was doubled to include inhalation, was 5% (child) of the lowest observed adverse effect level (LOAEL) and 1 percent of the LOAEL for adults. Similarly, the calculated exposure dose for the highest concentration of PCE in a private well was 1 percent of the LOAEL for children and less than 1percent for adults.

It is anticipated that the actual exposure was less in both instances because the most health protective assumptions were used to calculate the exposure dose. These assumptions included the use of the maximum water intake rates and the maximum contaminant concentration in exposure calculations. As previously discussed, the effects of dilution and contaminant volatilization in the water storage systems were not considered. Therefore, non-cancer adverse health effects are not anticipated from drinking the municipal or private well-water.

The additional cancer risk was calculated for drinking water from well #2A contaminated with PCE (see Table 6, Appendix C). The cancer risk was calculated using EPA's cancer slope factor published in 2012 [IRIS PCE]. The cancer potency factor decreased dramatically from previous EPA draft documents. The lower value for the cancer slope factor results in a large decrease in the cancer risk calculated for the PCE exposures.

The increase in the lifetime cancer risk associated with consumption of the highest concentration of PCE in municipal well #2A water was "very low" at two to four cases per million people exposed. The additional cancer risk for drinking water from the PCE contaminated private wells was also very low (see Table 7, Appendix C).

Trichloroethylene

Trichloroethylene (TCE) is a non-flammable liquid used as a solvent to remove grease from metal parts. It may also be found as a component of household products such as paint removers, adhesives, carpet cleaners and spot removers. EPA has identified trichloroethylene contamination at more than 1,500 hazardous waste sites in the U.S.

Occupational studies show adverse health effects associated with breathing trichloroethylene. The health effects include drowsiness, headaches, fatigue, difficulty concentrating, and eye irritation. Exposure for long periods may cause nerve, kidney, and liver damage. Breathing very high concentrations of trichloroethylene may cause impaired heart function, unconsciousness, and death [ATSDR TCE].

There is limited human data available on non-cancer health effects of drinking water contaminated with trichloroethylene. Drinking small amounts of trichloroethylene for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear. Skin contact with trichloroethylene for short periods may cause skin rashes.

Animal studies demonstrate ingestion of trichloroethylene can damage the liver, kidneys, and central nervous system. Other adverse health effects include a decrease in the thymus weight, fetal heart malformations, and immune system impacts.

Trichloroethylene was present at levels above ATSDR's screening value in four samples from municipal well #2A and three of the private well samples. The exposure dose was calculated based on the highest concentration of trichloroethylene in municipal well #2A. The exposure dose from the municipal water exceeded EPA's (non-cancer) long-term health guideline for both children and adults. Trichloroethylene was not detected in private wells #1, #2, and #3. Exposure doses calculated for private wells #4, #5, and #6 were also above EPA's health guideline.

The exposure dose exceeded the 99^{th} percentile human equivalent dose ($HED_{99,LOAEL}$)2 for children less than 6 years of age [IRIS TCE]. If the exposure dose is doubled to account for inhalation and dermal exposures while showering, the exposure dose approached or exceeded the 99^{th} percentile human equivalent dose for all age categories. Therefore, people who drank TCE contaminated municipal water from 1984 to 1988 may have experienced adverse health effects.

The exposure dose also exceeded the 99^{th} percentile human equivalent dose ($HED_{99,BMDL01}$) that resulted in increased fetal cardiac malformations in rats. Therefore, pregnant women who drank TCE contaminated municipal water may have experienced an increased risk of having a child with fetal heart malformations.

The exposure dose calculated for the three private wells also exceeded EPA's (non-cancer) health guideline for all age categories. If the exposure dose was doubled to account for inhalation and dermal exposures while showering, the exposure dose for children less than 1 year of age was about 23 percent of the $HED_{99,LOAEL}$ for private wells #4 and #6. The exposure dose for a child less than 1 year of age drinking water from private well #5 was approximately 10% of the $HED_{99,LOAEL}$. Only one drinking water sample was collected from the private wells. The TCE concentration and consequently exposure dose could have varied over time. Therefore, it is possible that residents using the 3 private wells could have experienced adverse health effects related to drinking TCE contaminated water.

Epidemiology (human) studies have reported kidney cancer associated with drinking water contaminated with TCE. There is also some evidence from epidemiology studies that non-Hodgkin lymphoma and liver cancer may also be associated with TCE. Results of animal studies showed that TCE may cause liver, kidney, or lymph system cancer. The U.S. Department of Health and Human Services has determined that trichloroethylene is "reasonably anticipated to be a human carcinogen" based on the epidemiological human and animal studies. The IARC has concluded that trichloroethylene is "probably carcinogenic to humans." The EPA has concluded that TCE is carcinogenic to humans [IRIS TCE].

The increased cancer risk was calculated based on consumption of the highest measured concentration of TCE in municipal well #2A for four years. An age-dependent adjustment factor was applied because TCE has a mutagenic mode of action (EPA Risk Assessment Handbook). The age adjustment is designed to account for the increased susceptibility of children. The additional lifetime cancer risk associated with a child consuming TCE contaminated water from well #2A was five to 10 cases per 10,000 people exposed. This is considered a "moderate to

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2 $HED_{99, LOAEL}$ is the 99th percentile human equivalent dose to the mouse lowest observed adverse effect level. EPA used the 99^{th} percentile because of uncertainty and variability in the model.

high” cancer risk (see Table 6). The additional cancer risk for adults was three to six cases per 100,000 people exposed. This is considered a “low” cancer risk.

The increased cancer risk was also calculated for the private wells tested near the site (see Table 7, Appendix C). A 33-year exposure period was used because it approximates the maximum time (95^{th} percentile) a person lives at one location. A 21-year exposure period was used to calculate a child’s cancer risk. The date the wells were initially contaminated is unknown. The additional cancer risk associated with consuming water contaminated with TCE was calculated as “low” for a child and “very low” risk for adults. The private wells were closed and residents provided municipal water in 1989.

CONCLUSIONS

A contaminated well (#2A) was donated to the town of Old Fort and connected to the municipal water system for 2.5 years to 4 four years in the mid-1980s. The contamination was detected in December 1987. Well #2A was disconnected from the municipal water system in January 1988. Contamination was also detected in three private drinking water wells near the United Merchants and Manufacturing site in 1989. The residents were immediately connected to the municipal water system.

DPH concludes that drinking municipal water contaminated with trichloroethylene could have harmed people’s health. The exposure dose calculated using the highest TCE level is greater than the human equivalent dose of the LOAEL in mice. The possible non-cancer side effects include decreased thymus weight and fetal heart malformations. The increased cancer risks for drinking or breathing municipal water for four years was “moderate to high” for children less than 4 years of age. For adults, the increased cancer risk from drinking municipal water was “low”.

DPH concludes drinking water from private wells contaminated with TCE could have harmed the health of children less than 1 year of age. The exposure dose from drinking contaminated water was 23 percent of the human equivalent dose of the LOAEL in mice. It is not known when the three private wells were contaminated, how long the wells were used, or if the single data point is representative of the contamination level. The increased cancer risk was “low” for children and “very low” for adults.

DPH concludes drinking municipal water or private well water contaminated with tetrachloroethylene is not expected to harm people’s health. The highest exposure dose doubled to account for inhalation was 5 percent of the human LOAEL. The additional cancer risk from drinking municipal water contaminated with PCE was very low. The additional cancer risk from drinking water from the private drinking water wells was also very low.

DPH concludes that drinking or breathing the other contaminants present in the municipal and private well water of (carbon tetrachloride, chloroform, 1,1-dichloroethylene, 1,2-dichloroethylene, and 1,1,1-trichlorethane) are not expected to harm peoples health.

Adverse health effects from PCE or TCE are not expected at the former Nichols Laundry or Gateway Museum based on the indoor air measurements. However, the subsurface soil gas concentration of PCE was 30,000 µg/m^3 at the former Nichols laundry and 6,300 µg/m^3 at the Gateway Museum. These levels exceed vapor intrusion screening levels and indicate that higher exposures are possible.

Vapor intrusion is not currently anticipated at Old Fort Elementary School because the PCE plume from the former Nichols Laundry site is more than 100 feet from the school (EPA Vapor Intrusion). A sewer system intake leak at the waste water treatment plant is not a viable scenario for vapor intrusion at Old Fort Elementary School. No sewer system leaks were documented near the school.

RECOMMENDATIONS

The DPH makes the following recommendations:

- DPH and McDowell County Health Department will inform the community of possible risks associated with past exposure to contaminants in the municipal drinking water.
- DPH and McDowell County Health Department will attempt to locate and inform individuals that used the 3 contaminated private drinking water wells of possible risks associated with the contaminated water.
- DPH will inform local health care providers of the possible health effects associated with consumption of contaminated municipal or private drinking water wells. Persons concerned about possible adverse health effects associated with past exposure should discuss the sampling results with their personal physician.
- DPH will request an updated analysis of the types of cancer and cancer rates for the community from the Central Cancer Registry. The results of the analysis will be shared with the community.
- NC DENR should continue the groundwater investigation/remediation process at the former Nichols Laundry and Dry Cleaning site.
    - Persons working in the flower shop and Gateway Museum should be informed of the on-going potential for TCE and PCE from vapor intrusion.
    - If remediation efforts cannot prevent the contamination from continuing to migrate towards Old Fort Elementary School, an air monitoring process should be considered to evaluate the potential for exposure of students and staff at the school.

References

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Appendix A: Photographs and Figures



Aerial Photo Old Fort in 1993



Old Fort Wastewater Treatment Plant in 1993



Former Nichols Laundry and Dry Cleaning



Old Fort Finishing site



Old Fort Elementary School

Figure 1: Tetrachloroethylene (PCE) Contamination Plume

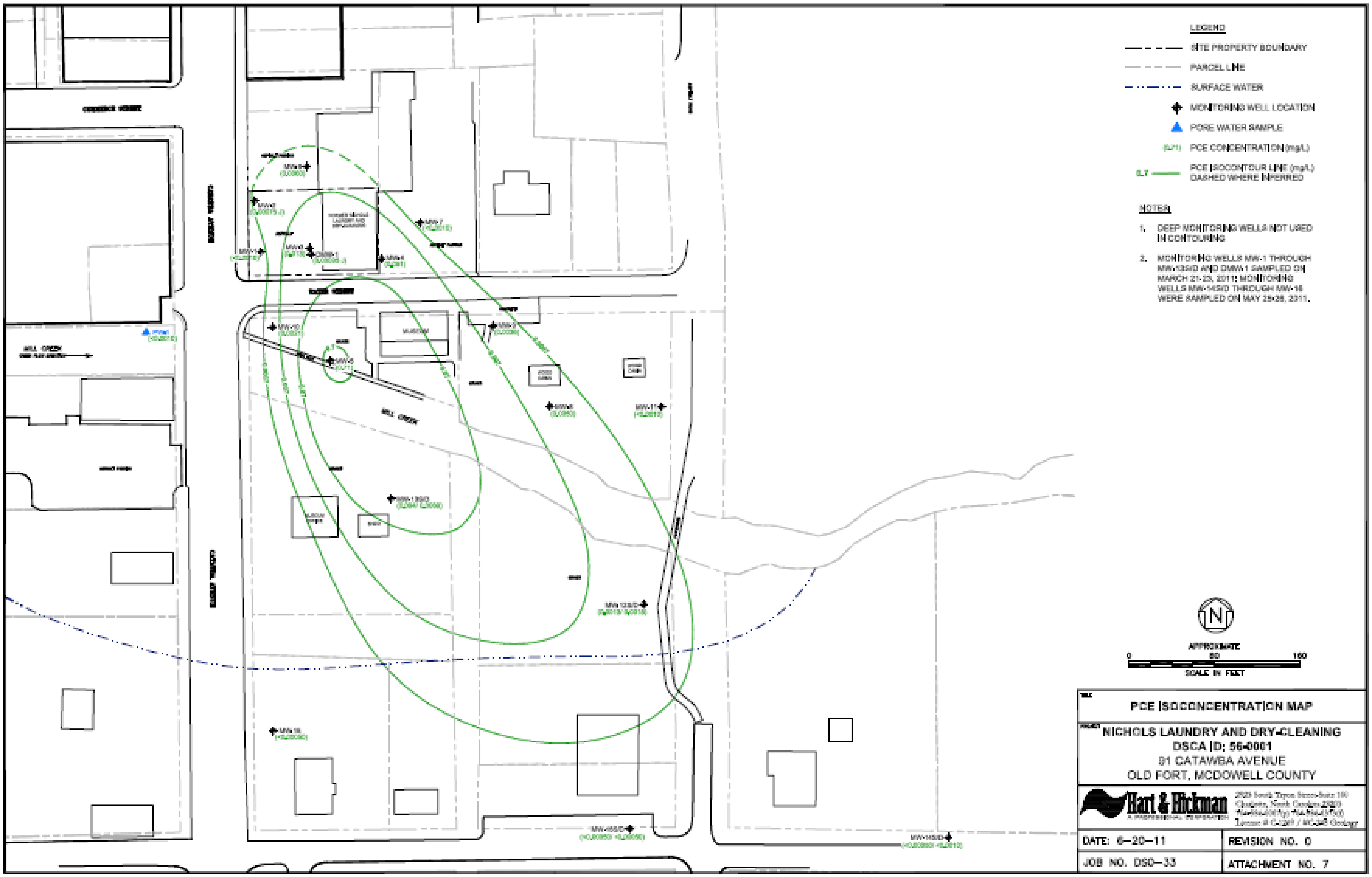


Figure 2: Gateway Museum Air Sample Locations

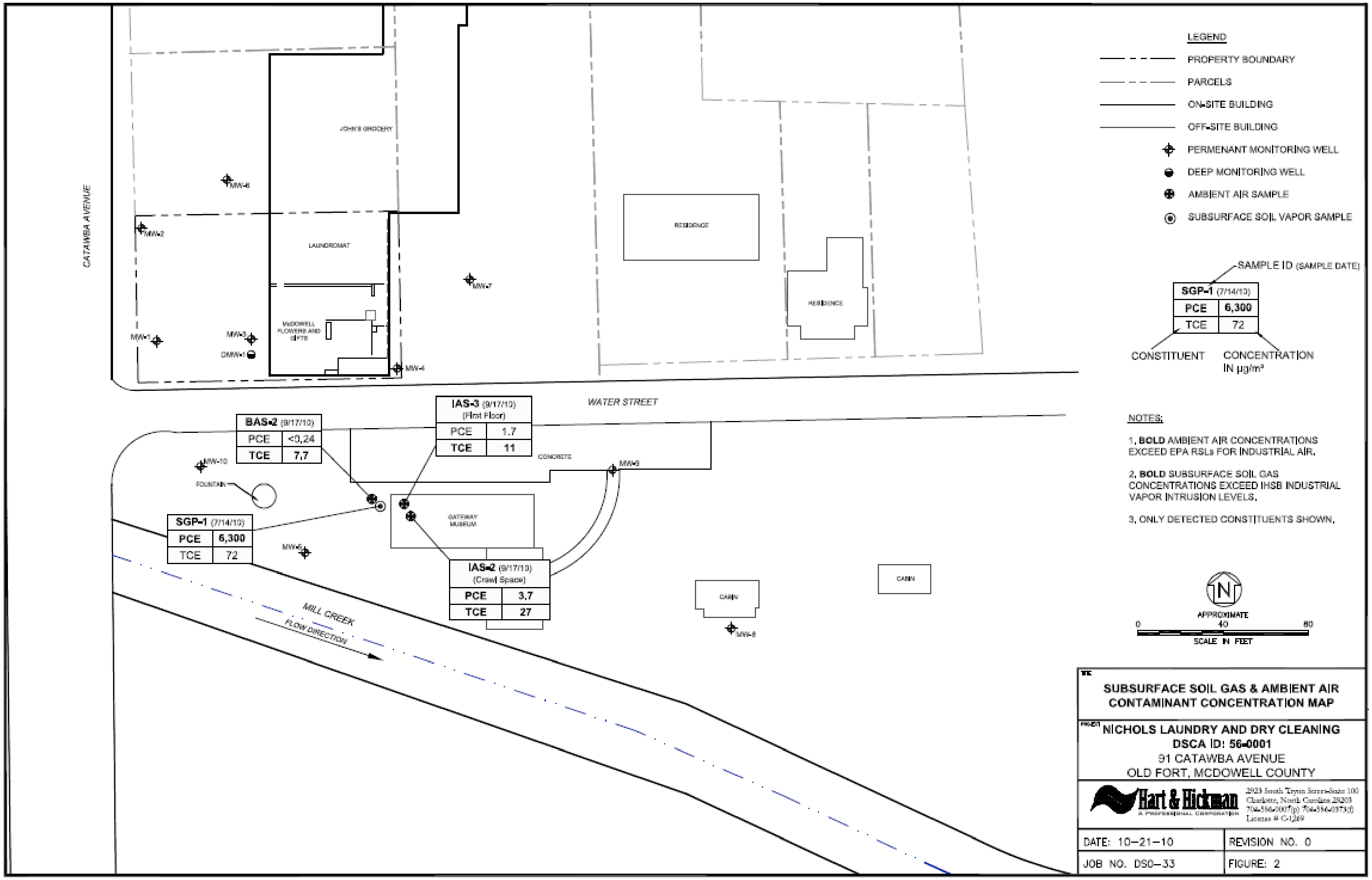
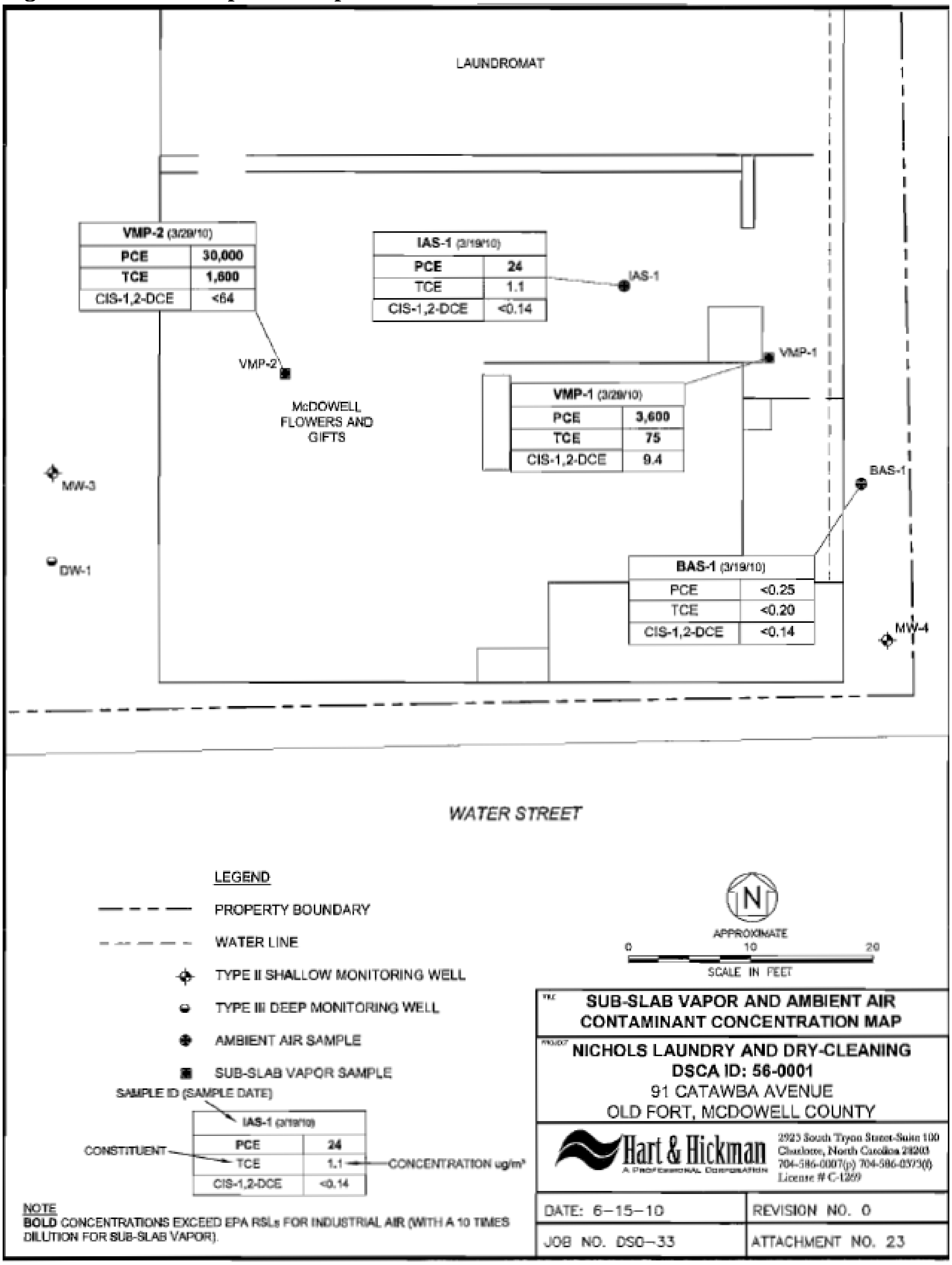


Figure 3: Flower Shop Air Sample Location



Appendix C: Tables

Table 4: Exposure Dose for Contaminants in Municipal Well #2A Drinking Water

Contaminant	Highest Concentration µg /L[1]	Age Group	Calculated dose mg/kg/day[2] RME[3]	Calculated dose mg/kg/day[2] CTE[4]	Health Guideline mg/kg/day[2]
1,2-Dichloroethene	79.1	Birth to <1	0.01129	0.00511	0.002[5]
		1 to < 2	0.00620	0.00213	
		2 to <6	0.00478	0.00183	
		6 to <11	0.00311	0.00119	
		11 to <21	0.00252	0.00093	
		21 to <65	0.00282	0.00117	
		65 to 78	0.00271	0.00129	
Tetrachloroethylene	448.4	Birth to <1	0.0640	0.0290	0.006[5]
		1 to < 2	0.0351	0.0121	
		2 to <6	0.0271	0.0104	
		6 to <11	0.0176	0.0068	
		11 to <21	0.0143	0.0053	
		21 to <65	0.0160	0.0066	
		65 to 78	0.0154	0.0073	
Trichloroethylene	790.9	Birth to <1	0.1186	0.0511	0.0005[5]
		1 to < 2	0.0619	0.0214	
		2 to <6	0.0478	0.0183	
		6 to <11	0.0311	0.0119	
		11 to <21	0.0252	0.0093	
		21 to <65	0.0282	0.0117	
		65 to 78	0.0271	0.0129	

Note: Gray shading indicates concentration exceeded the Health Guideline
[1]Micrograms per Liter
[2]Milligram per Kilogram per Day
[3] Reasonable Maximum Exposure (95% percentile) Water Intake Rates
[4] Central Tendency Exposure (mean) Water Intake Rates
[5]Oral Reference Dose (EPA)

Table 5: Exposure Dose for Contaminants in Private Wells

Contaminant	Well #4 mg/kg/day[1]		Well #5 mg/kg/day		Well #6 mg/kg/day		Health Guideline mg/kg/day
Tetrachloroethylene	RME	CTE	RME	CTE	RME	CTE	0.006[2]
Birth to < 1	0.01806	0.00818	0.00638	0.00288	0.00741	0.00335	
1 to < 2	0.00992	0.00342	0.00350	0.00127	0.00407	0.00140	
2 to <6	0.00765	0.00292	0.00270	0.00107	0.00314	0.00119	
6 to <11	0.00498	0.00191	0.00176	0.00067	0.00204	0.00078	
11 to <21	0.00403	0.00148	0.00142	0.00052	0.00165	0.00060	
21 to <65	0.00451	0.00187	0.00159	0.00066	0.00185	0.00076	
65 to 78							
Trichloroethylene	RME	CTE	RME	CTE	RME	CTE	0.0005[2]
Birth to < 1	0.00557	0.00252	0.00215	0.00098	0.00549	0.00248	
1 to < 2	0.00306	0.00105	0.00118	0.00041	0.00302	0.00104	
2 to <6	0.00236	0.00091	0.00091	0.00035	0.00233	0.00088	
6 to <11	0.00153	0.00058	0.00059	0.00023	0.00151	0.00058	
11 to <21	0.00124	0.00045	0.00048	0.00018	0.00122	0.00045	
21 to <65	0.00139	0.00057	0.00054	0.00022	0.00137	0.00057	
65 to 78							

Note: Gray shading indicates concentration exceeded the Health Guideline

[1]Milligram per kilogram per day

[2]Oral Reference Dose (EPA)

Table 6: Increased Cancer Risk from Ingestion of Municipal Well #2A Water

Contaminant	Highest Concentration µg /L[1]	Cancer Slope Factor	Number of Additional Cancers Predicted Child (birth to 4)	Number of Additional Cancers Predicted Adult	Additional Risk
Carbon Tetrachloride	<1	0.07	<1 per million	<1 per million	None
Tetrachloroethylene	448.4	0.0021	2 to 4 per million	<2 per million	Very low
Trichloroethylene[2]	790.9	0.0046	5 to 10 per 10,000	3 to 6 per 100,000	Child - Moderate to High Adult - Low

[1]Micrograms per Liter

[2]Age Dependent Adjustment Factor applied

Table 7: Increased Cancer Risk from Ingestion of Private Well Water

Contaminant	Concentration µg /L[1]	Number of additional cancers predicted child[2]	Number of additional cancers predicted adult[3]	Additional Risk
Tetrachloroethylene Well #4 Well #5 Well #6	126.6 44.7 51.9	1 to 3 per million 1 per million 1 per million	2 to 4 per million 1 per million < 2 per million	Very Low Very Low Very Low
Trichloroethylene[4] Well #4 Well #5 Well #6	39.0 15.1 38.5	4 to 10 per 100,000 2 to 4 per 100,000 4 to 10 per 100,000	1 to 3 per 100,000 3 to 10 per million 1 to 3 per 100,000	Low Very Low Low

[1]Microgram per Liter
[2] Child exposures from birth to 21 years
[3] Adult exposures based on 33 years
[4]Age Dependent Adjustment Factor applied

Table 8: Increased Cancer Risk for Vapor Intrusion

Contaminant	Location	Highest[1] Concentration µg/m³	Inhalation Unit Risk per µg/m³	Number of Additional Cancers Predicted	Additional Risk
Tetrachloroethylene	Museum	1.7	2.6E-7	<1 per million	None
	Flower Shop	24	2.6E-7	<1 per million	None
Trichloroethylene[2]	Museum	11	4.1E-6	3 per million	Very Low
	Flower Shop	1.1	4.1E-6	<1 per million	None

[1]Microgram per Cubic Meter of Air
[2]Age Dependent Adjustment Factor applied